ABSTRACT

A device is described which permits the use of an electron microscope to irradiate materials with low energy (50 - 150 Kev) electrons. With the device the electron beam current can be monitored quickly and accurately so that the irradiation rate can be closely controlled. The device was developed for use in the Hitachi HU-11 electron microscope but with minor modifications can be utilized with other microscopes as well.

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AN ELECTRON DENSITOMETER FOR IRRADIATION STUDIES
in the ELECTRON MICROSCOPE

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Introduction:

Ceramic materials, selected for use as window components over photo-detectors on a proposed earth satellite, were investigated for fluorescence under direct electron bombardment of these windows utilizing energy levels of 50, 75 and 100 kilovolts in the Hitachi HU-11 Electron Microscope.

Empirical calculations concerned with the electron optics, geometry, electrical systems and their general inter-relations were first considered using the following relationship:

$$\gamma = R \cdot \pi \alpha^2$$

where γ = current density of the focused spot

R = current density per unit solid angle or the "Richtstrahlwert"

α = illuminating angle

The theoretical considerations put forth by Haines et al in various publications (1) - (4) relating the parameters involved in the evaluation of the current density per unit solid angle, or brightness, was first investigated in an attempt to evaluate our electron optical system. At the very outset, it was ascertained that the variables involved were too numerous' and the experimental procedures too complicated to render acceptable data; therefore, a device employing the Faraday Cage principle was so constructed as to be compatible with the geometry of the electron microscope. The device

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also served as a specimen holder so that both flux density measurements and specimen irradiation could be carried out without breaking the specimen chamber vacuum. This device was successfully employed to monitor the variations in the electron flux density preselected for this experiment.

General Description:

The Probe head, which attaches to the high resolution reflection - diffraction unit supplied with the Hitachi HU-11 electron microscope, is composed basically of a lucite block (3) Fig. 1, onto which a 40 millimeter stainless steel circular plate is attached (2) Fig. 1 Four millimeters directly above and below the collector plate is a tungsten mesh grid 40 millimeters in diameter (1). Fig. 1 and (7) Fig. 2. Equidistant from the center line of the lucite block and on the reverse side is the specimen stage (6) Fig. 1 onto which various materials can be mounted for study.

Underneath the mounted specimen is a brass conductor plate (8) Fig. 3 which is fastened to the lucite block. Overlying the specimen is a blackened brass disc (9) Fig. 3 with a 6 millimeter aperture centrally located. The specimen and its retaining mask are held firmly in place by four adjustable spring clamps (5) Fig. 1. Any charging of the surface generated by impinging electrons on a non-conducting specimen will be conducted to ground preventing the charging and discharging of the specimen.

Experimental Procedure:

A fluorescent screen is placed on top of the tungsten grid (1) Fig. 1 and the optical system is aligned and preset for the maximum spot diameter in the high resolution position, Fig. 5. This is accomplished by placing the intermediate magnetic lens control at its maximum milliampere setting. The diameter of the circle of illumination is then carefully measured with a binocular microscope utilizing a micrometer eyepiece parallel to the fluorescent screen. The diameter of the illuminated area will remain constant over a wide range of electron flux densities which is varied by the movement of the second condensed magnetic lens control.

In operation at 50,000 electron volts, a negative bias was placed on the outermost tungsten circular grid in order to minimize primary reflections and secondary emissions of electrons impinging on the collector plate surface (2) Fig. 1. It is found on the experimental configuration that the difference in the recorded current with a zero to 100 volt bias is not detectable and the grid bias was eliminated as an experimental parameter. Next, the second condenser magnetic lens control was varied until the desired flux density was recorded on an electrometer. When the flux density had been determined, the probe was rotated about its axis so as to orient the specimen at a prescribed angle to the beam. Auxillary devices were employed to detect the presence, amount and character of the fluorescence.

The disadvantages encountered in the use of this device are mainly concerned with its geometry, and its compatibility with the geometry of the electron microscope. These salient points have been taken into consideration in a newly designed probe assembly (see Fig. 4). The new probe can be installed into the microscope and can be used in conjunction with or intermittently with normal electron microscopic procedures. The alignment of beam, speciment and densitometer is controlled by the movement of the two adjusting micrometer screws (Fig. 4). Specimens of various structures can be accommodated in the probe by the movement of the variable height adjustment screw.

Conclusions and Applications:

This device enables the user to subject bulk specimens to electron irradiation of controlled, stable energy levels over a wide range of electron flux densities. No alterations are necessary to existing Hitachi HU-11 and HU-11a electron microscope systems. The conversion from the material irradiating geometry to the normal microscopy and diffraction geometry is accomplished rapidly. This device will be of use in the study of electron radiation damage to crystals, electronic devices, thin metallic films, ceramics, and polymers in the low electron energy ranges and dose levels similar to orbital missions of various earth satellites.

References

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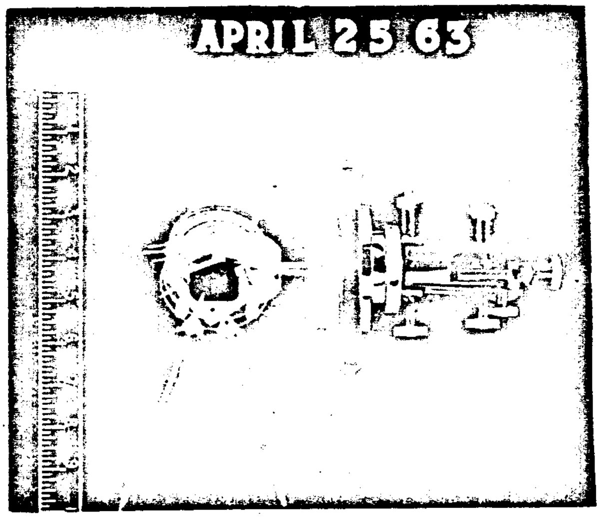
3. V. E. C sslett, Electron Optics, Clarendon Press, Oxford, 1950

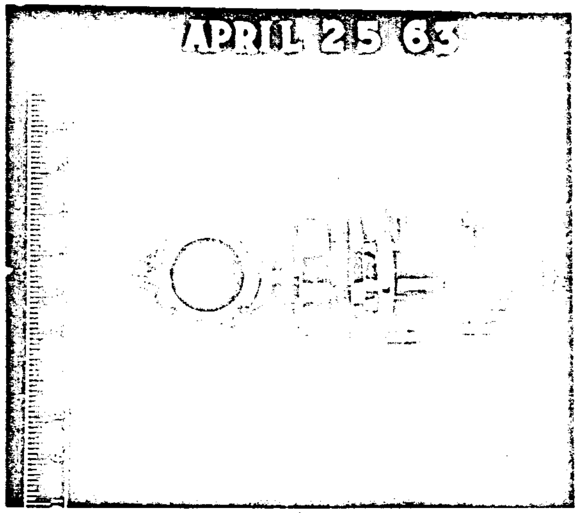
4 V. K. Zworykin, G. A. Morton, E. G. Ramberg, J. Hillier, and A. W. Vance, Electron Optics and the Electron Microscope, J. Wiley & Sons, New York, 1945



#9 Mask

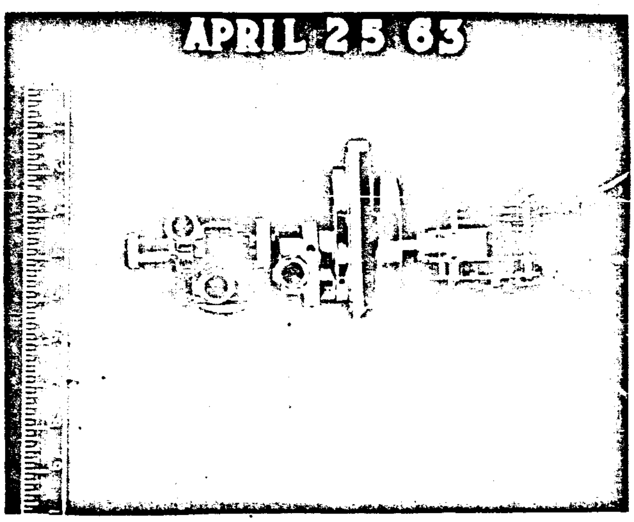
#8 Grounding Plate

FIGURE #3



#7 Tungsten Grid

FIGURE #2



#1 Tungsten Grid

#2 Collector Plate

#3 Lucite Block

#4 Specimen Spacer

#5 Specimen Retainer

#6 Specimen Stage

FIGURE #1

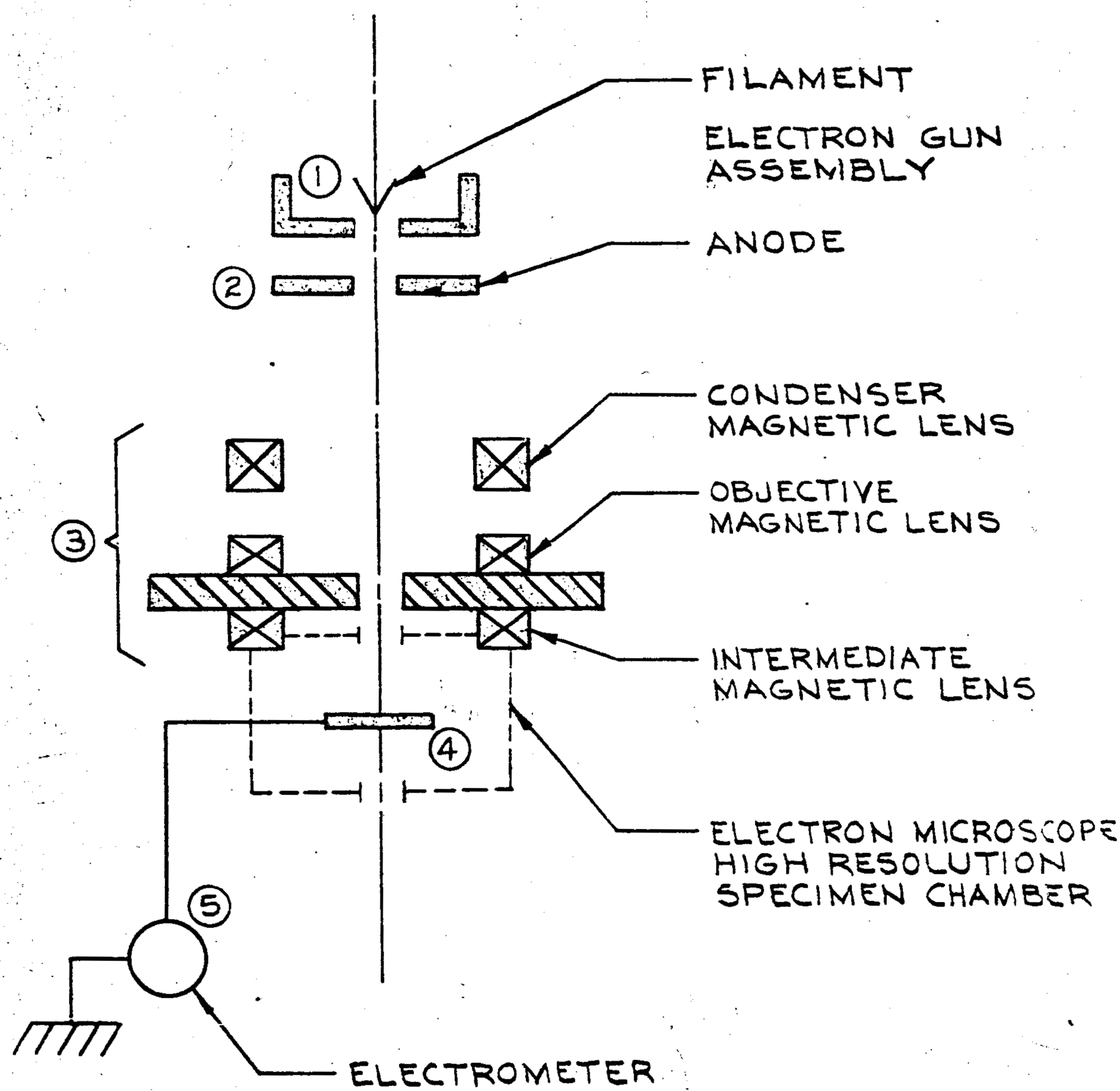

FILAMENT
ELECTRON GUN
ASSEMBLY
1
ANODE
2
CONDENSER
MAGNETIC LENS
OBJECTIVE
MAGNETIC LENS
3
INTERMEDIATE
MAGNETIC LENS
4
ELECTRON MICROSCOPE
HIGH RESOLUTION
SPECIMEN CHAMBER
5
ELECTROMETER

FIGURE 2

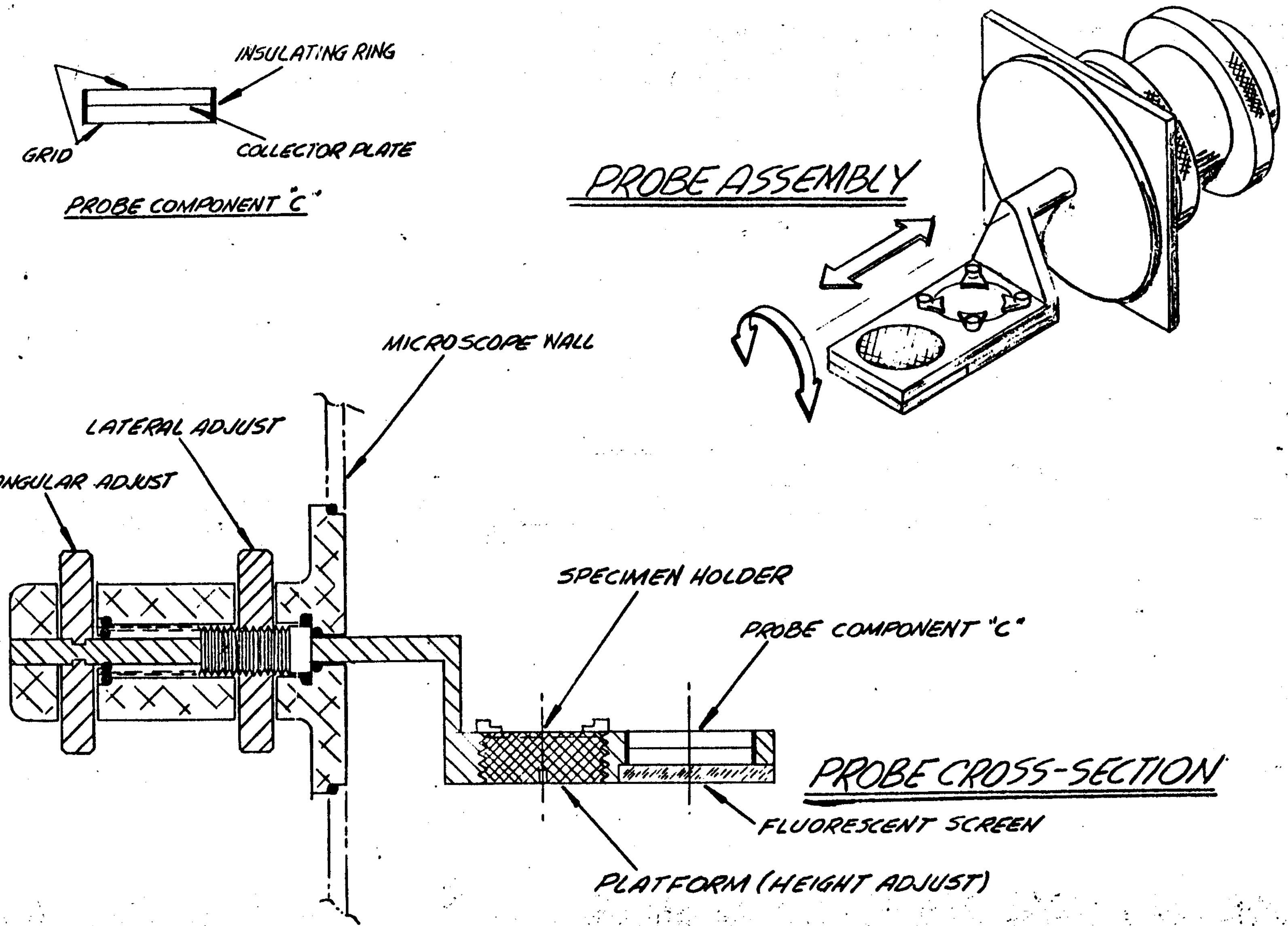

INSULATING RING
GRID
COLLECTOR PLATE
PROBE COMPONENT "C"
PROBE ASSEMBLY
MICROSCOPE WALL
LATERAL ADJUST
ANGULAR ADJUST
SPECIMEN HOLDER
PROBE COMPONENT "C"
PROBE CROSS-SECTION
FLUORESCENT SCREEN
PLATFORM (HEIGHT ADJUST)

FIGURE 4